A NEVV QUADRANT, OF More Naturall, Easie, and Manifold Performance, than any other heretofore Extant,

Framed according to the Horizontall Projection of the Sphere, with the Uses thereof.

By *C. B.* Maker of Mathematic Instruments in METALL.

LONDON,
Printed in the Yeare 1649.

TO

My Singular good Friend Mr WILLIAM BADILEY, Mariner, and a lover of the Mathematics.

Worthy Sir,

HAving diligently inquired the reason of the projection of the Sphere into plaine, as the ground of all Mathematic Instruments (the making whereof in Metall is my Trade and Livelihood) and compared the severall manners; I found none so genuine, simple, easie, and manifoldly usefull, as is the Horizontall; which lively representeth the Globe rectified to some certaine elevation, and naturally performeth the uses thereof. And having likewise compared the severall Quadrants, and pocket Instruments hitherto made, and finding them all pieced up with many unnaturall and forced lines and divisions, presupposing an exact diligence both in the Calculator,

tor, and in the workman; and yet the performance difficult, troublesome, and tedious: I bethought my self whether out of the Horizontall projection I might not by some smal alteration frame a Quadrant, that might remedy the defects of all the former Instruments, and that with greater ease and certainty. And having by the help of God happily attained my desired intent, my many respects represented you under whose Approbation and Patronage I might send out into public view this my new Quadrant, with the many Uses thereof; as being one to whom I stand obliged for your love and manifold favours to mee both at Sea in divers Voiages, and at land; and who through your skill in the Mathematicall Sciences are able to judge and patronize the first attempts of

Your affectionately

devoted Servant,

C. B.

THE
Description of the Quadrant,
and the parts thereof.

THe limbe of the Quadrant divided into 90 Degr. representeth the Horizon.

That side of the Quadrant where the Sights are, is the Meridian, or XII a Clocke line, unto which is joyned the scale of Moneths with every fift Day, untill they grow so little toward the Solsticeas, that they cannot bee distinguished. This scale hath five Rowes, the midst whereof hath the very same divisions which are on the Meridian line: The two next on both sides are for the parts of the Moneths, which in the two outermost Rowes are noted by their first Letters.

The other side of the Quadrant hath on it the scale of Altitudes above the Horizon.

The short Arching lines within the Quadrant beside the Meridian, are Houre-lines, noted by their Figures, both for the forenoone, and after-

noon; and halfe Houre lines: each halfe houre containing 30 min. of an hour, or Deg. 7°. 30'. Of these Horary lines, those which serve in the morning before the Sunne is full East, or in the evening past the West, (which is onely in Summer halfe yeare) are reversed. And all the Hour lines are noted with two Figures; whereof the upper next the Center and scale of Altitudes, serve for the afternoon; and the lower for the forenoon. The two Arches which crosse the Houre lines, and meet at the beginning of the Horizon and scale of Altitudes, are two Quarters of the Ecliptic, and are divided into 90 Degr. a piece, in which are noted the XII Signes by their proper Characters, namely on the upper next the Center are ♈ ♉ ♊ & ♋ ♌ ♍, the Summer or Northerne Signes: and on the lower next the Horizon are ♎ ♏ ♐ & ♑ ♒ ♓, the Winter or Southerne Signes, and contain 30 Degr. a piece. This is the Circle of the Sunnes annuall motion.

The long Arches, which beginning at the Scale of moneths in the Meridian betwixt the two Quarters of the Ecliptic, crosse all the Houre lines, are the parallels of Declination, or the Semidiurnall Arches of the Sunne; the middlemost of which is the Equinoctiall, the outermost above is the Tropick of ♋, and the outermost below is the Tropick of ♑: although between

between the Equinoctiall and each Tropick Innumerable parallels are understood to be contained, yet those which are in the Instrument drawne, at every second Degree of Declination, may be sufficient to direct the eye in tracing out an imaginary parallel from every point given in the Scale of moneths.

The Equinoctiall and every tenth parallel are for distinction sake made somewhat grosser than the rest, and all the *Summer* parallels at the East and West line are continued reversedly back unto the Horizon.

Note that upon the right estimation of that imaginary parallel, the manifold use of this Instrument doth especially rely; because the true place of the Sunne all that day is in some part or point of the same Circle.

And note that in this Instrument, the direct Horary lines, and parallels before their reversion, shew the houre of the day like a direct South upright Diall: And the Arches of them reversed serve like a direct North upright Diall.

Use I. *To finde the Declination of the Sun every day.*

Seek the day proposed in the Scale of moneths very exactly, & mark upon what point it falleth in the middle Row of that Scale, or (which is all one) in the Meridian, for there is the Decli-

clination of the Sunne from the Equinoctiall, either North or South: which if it fall not directly upon a parallel, but in the ſpace between two, ſuppoſing each halfe of that ſpace to containe 60 minutes, eſtimate with your eye proportionally what minute the point giveth.

Example 1. What is the Sunnes Declination upon *Novemb.* 13? the day will fall in the ſpace after 20 Degrees, from the Equinoctiall Southward, about 30 minutes: Wherefore the Sunnes Declination is 20°. 30′ South.

Example 2. What is the Sunnes Declination upon *Auguſt* 19? the day wil fal in the ſpace after 8 Degrees, from the Equinoctiall Northward, one Degree and about 40 minutes: Wherefore the Suns Declination is 9°. 40′. North.

Note that the Declination thus found is to be kept in minde all the day.

Uſe II. *To finde the Semidiurnall Arch, or parallel Circle in which the Sunne moveth every day.*

Seeke out the true point of the Sunnes Declination upon the Meridian by *Vſe I*: then from that point by the eſtimation of your eye, trace out an imaginary parallel: which when it commeth to the Eaſt and Weſt line (as in all Northerne parallels it doth) is to bee reverſed unto the Horizon or Limbe at the ſame proportionable

tionable distance as before. This operation requireth exact diligence.

Use III. *To finde the time of the Sunes Rising and Setting every day.*

Seek out the imaginary parallel, or Semidiurnal Arch of the Sun for that day by *Vse II*, and marke where it meeteth with the Horizon; for that is the very point of the Sunnes rising and setting, and the Hour-lines on both sides of it, (by proportioning the distance reasonably, according to 30 minutes for halfe an houre) will shew the time of the Sunnes rising and setting.

Thus at *London*, *Novem.* 13. the Sun will be found to rise at 9 min. before 8, and to set at 9 min. after 4. Also *August* 19, the Sunne will be found to rise 12 min. after 5. and to set 12 min. before 7.

Use IV. *To finde the Suns Amplitude, Ortive and Occasive: that is, how many Degrees of the Horizon the Sunne riseth and setteth from the true East and West points every day.*

The imaginary parallel of the Sunne, together with the time of the Sunnes rising and setting, sheweth upon the Horizon the Degree of his Amplitude from East and West, which in all the Northerne parallels is on the North side, and in the Southerne on the South side.

Thus at *London*, *Novem.* 13. the Ampl. Ort. will

will be found 34 Degrees. Also *Aug.* 19. the Ampl. Ort. will be found 15°. 10'.

Use V. *To find the Length of every day and night.*

Double the houre of the sunnes-setting, and you shal have the Length of the day: or double the houre of the sunnes-rising, and you shall have the Length of the night.

Use 6. *To know the reason and manner of the Increasing and Decreasing of the Dayes and Nights throughout the whole yeare.*

When the Sunne is in the Equinoctial, it riseth and setteth at 6 a Clocke: But if the Sunne be out of the Equinoctial, declining toward the North, the Intersection of the parallel of the Sunne with the Horizon is before 6 in the morning, and after 6 in the evening; and the Diurnall Arch greater than 12 houres, and so much more great, the greater the Northerne Declination is. Againe, if the Sunne be declining toward the South, the Intersection of the parallel of the Sunne with the Horizon is after 6 in the morning, and before 6 in the evening; and the Diurnall Arch lesser than 12 hours, and by so much lesser, the greater the Southern Declination is.

And in those places of the Ecliptic in which the Sunne most speedily changeth his Declination, the Length also of the day is most altered;

altered; and where the Ecliptic goeth moſt parallell to the Equinoctiall, changing the Declination ſlowly, the length of the day is but little altered. As for Example; When the Sun is neare unto the Equinoctiall on both ſides, the dayes Increaſe and alſo Decreaſe ſuddenly and apace; becauſe in thoſe places the Ecliptic inclineth to the Equinoctiall in a manner like a ſtraight Line, making ſenſible Declination. Againe, when the Sunne is neare his greateſt Declination, as in the height of Summer, and the depth of Winter, the dayes keep for a good time, as it were, at one ſtay; becauſe in theſe places the Ecliptic is in a manner parallel to the Equinoctiall, the Length of the day differeth but little, the Declination ſcarce altering; and becauſe in thoſe two times of the yeare, the Sunne ſtandeth as it were ſtill at one Declination, they are called the Summer Solſtice, and Winter Solſtice. Wherefore wee may hereby plainely ſee, that the common received opinion, that in every moneth the dayes doe equally increaſe, is erroneous. Alſo wee may ſee, that in parallels equally diſtant from the Equinoctiall, the day on the one ſide is equall to the night on the other ſide.

Uſe VII. *To take the height of the Sunne above the Horizon.*

Hold the edge of the Quadrant againſt the Sunne,

Sunne, so that the Sunnes Ray or Beam may at once passe through the hole of both the sights; then shall the thread with the Plummet shew the Sunnes Altitude.

Use VIII. *To finde the Houre of the day, or what a clock it is.*

Having the imaginary parallel or Semidiurnall Arch of the Sunne, already found and conceived in your minde by *Vse II*, take the Sunnes height above the Horizon, then stretching the thread over the scale of Altitudes, set the Bead to the Altitude found, move your thread untill the Bead exactly falleth upon the imaginary parallel, for there is the houre sought; and that is the true place of the Sun in the Quadrant at that time; to bee estimated upon the Horary lines, either direct, or reversed, according as the parallel is.

Use IX. *To finde the Sunnes Azumith or Horizontall distance from the foure Cardinall points.*

The Bead being set to the houre of the day, as was shewed in the *Vse* next before, the thread shall in the Limbe cut the East or West Azumith; that is, how many Degrees of the Horizon the vertticall Circle in which the Sunne is, is distant from the East and West points: The complement of which number giveth the Azumith from the South Meridian

Meridian, if the Bead fell in the right parallels: But if the Bead fall upon the reverſed parts, the Azumith is to be accounted from the North Meridian.

Uſe X. *To finde the Meridian Altitude of the Sunne every day.*

Stretch the thread over the Meridian, and ſet the Bead to the true Declination of the Sunne therein; then apply the thread to the ſcale of Altitudes; and the Bead ſhall give the Meridian Altitude ſought.

Uſe XI. *To finde at what time the Sunne commeth to bee full Eaſt or Weſt every day in Summer.*

This is ſhewen by obſerving at what houre the imaginary parallel meeteth with the Eaſt and Weſt line, at which it beginneth to reverſe.

Uſe XII. *To finde how high the Sunne is above the Horizon at any houre, every day.*

Set the Bead to the point in which the imaginary parallel of that day croſſeth the houre given: then applying the thread to the ſcale of Altitudes, mark upon what Degree the Bead falleth; the ſame ſhall bee the Altitude of the Sun required.

Uſe XIII. *To finde how high the Sunne is being in any Azumith aſſigned every day: and alſo at what houre.*

Set

Set the Bead to the point in which the imaginary parallel of that day crosseth the Azumith assigned; There also shall bee the houre sought: Then applying the thread to the scale of Altitudes, marke upon what Degree the Bead falleth; The same shall be the Altitude of the Sun required.

These two last Uses serve for the Delineation of the ordinary Quadrants, as that of *Gemma Frisius*, *Munster*, *Clavius*, Master *Gunter*, &c. and also of *Rings*, *Cylinders*, and other Topicall Instruments; and for the finding out of the houre by a mans shadow, or by the shadow of any *Gnomon*, set either perpendicular, or else parallel to the Horizon.

Use XIV. *To finde the Sunnes Longitude, or place in the Ecliptic.*

The imaginary parallel of the day being exactly traced will cut in the Ecliptick the Signe and Degree wherein the Sunne is: and note, that each semicircle of the Ecliptic is doubly noted with Characters of the Signes; the first and third Quarters goe forward from the Equinoctial point unto the Meridian, containing ♈ ♉ ♊ & ♎ ♏ ♐: the second and fourth Quarters goe backe from the Meridian unto the Equinoctiall point, containing ♋ ♌ ♍ & ♑ ♒ ♓.

But because neare unto both Tropicks (namely

(namely from *May* 11, to *July* 10, in the height of *Summer*, and from *November* 13, to *Januarie* 12 in the depth of *Winter*) the Declination altereth ſo ſlowly, that the true place of the Sunne in the Ecliptic cannot be diſtinguiſhed with any certainty, worke according to this foure-fold Rule following.

1. Before *June* 10, out of the number of dayes from *May* 0, ſubduct 11: the remains ſhall be the Degrees of ♊: thus for *June* 3, (becauſe there is all *May* and three dayes of *June*) ſay 34—11=23 ♊, the place of the Sunne.

2. After *June* 10, out of the Number of dayes from *June* 0, ſubduct 10: the remains ſhall bee Degrees of ♋: thus for *July* 3, ſay 33—10=23 ♋, the place of the Sun.

3. Before *December* 13, out of the Number of dayes from *November* 0, ſubduct 13: the remaines ſhall be Degrees of ♐: thus for *December* 3, ſay 33—13=20 ♐, the place of the Sun.

4. After *December* 13, out of the Number of dayes from *December* 0, ſubduct 13: the remaines ſhall be Degrees of ♑: thus for *January* 3, ſay 34—13=21 ♑, the place of the Sunne.

Uſe XV. *To find the Suns Right Aſcenſion every day.*

Having

Having by *Use XIV.* found the place of the Sunne in the Ecliptic, mark diligently upon what houre, and as neare as you can estimate what minute it falleth, counting the houres in the first and third Quarters of the Ecliptic, from the Equinoctiall point; but in the second and fourth Quarters, from the Meridian: and adde thereto in the second Quarter six hours, in the third twelve houres, and in the fourth eighteen houres: so shall you have the Sunnes Right Ascension, not in Degrees, but in time, which is more proper for use.

Example, in ♌ 6. the Sunnes Right Ascension will bee eight houres, one halfe, and about three minutes; that is H: 8: 33. min. reckoning 30′ for halfe an houre.

Use XVI. *To find the Houre of the Night by the Starres.*

For this, I have set a little Table of five knowne Stars dispersed round about the Heavens, with their Declination and Right Ascension for *Anno Dom.* 1650. Namely the left shoulder of *Orion*, noted O. The heart of the Lion, noted ♌. *Arcturus* noted A: the Vulture volant, noted V. The end of the wing of *Pegasus*, noted P.

The

The Table.

	Declinat.		Rec. Asc.	
☉	5°	59′	N	H5 6′
☌	13	39	N	9 50
A	21	4	N	14 00
V	8	1-	N	19 34
P	13	15	N	23 55

THe Operation is thus; first by the height of the Starre taken, and the parallel of its Declination exactly traced, seek out the houre of the *Starre* from the Meridian, as before was taught for the houre of the Day by the *Sunne*. Secondly, out of the Right Ascension of the *Starre*, subduct the Right Ascension of the *Sun*; the remain[illegible] sheweth how long time from the Noone before the same *Starre* commeth into the Meridian. Lastly, if the *Starre* be not yet come to the Meridian, out of the houre of the *Starres* comming into the Meridian, subduct the houre of the *Starre*: but if the *Star* be past the Meridian, adde both the houres together; so shall you have the true houre of the Night.

Note, that if the hours out of which you are to subduct bee lesser than the other, you must adde unto them 24.

Vse XVII. *To finde out the Meridian-Line upon any Horizontall plaine.*

About the middle of your plaine describe a Circle; and in the Center thereof erect a

straight Piece of Wire perpendicularly. When the *Sunne* shineth, note the point of the Circle which the shadow of the Wire cutteth, which I therefore call the shadow point, and instantly by *Vse IX.* seeke the *Sunnes* Azumith from the *South* or North: keepe it in minde. Then from the shadow point, if your observation be in the foore-noon, reckon upon the circle an Arch equall to the Azumith kept in minde, that way the *Sunne* moveth, if the Azumith bee *South*: Or the contrary way if it bee North. But if your observation bee in the afternoone, reckon the North Azumith that way the *Sunne* moveth; Or the *South* Azumith the contrary way.

Lastly, through the end of the Azumith and the center, protract a Diameter for the Meridian line sought: which you may note with *S.* at the South end, and with N. at the North end.

You may also note the point of the Circle Diametrally opposite to the shadow point with ☉, because it is the Azumith place of the Sun, at the moment of your observation.

Use XVIII. *To finde the Declination of any Wall or plaine.*

The safest way (because the Magneticall Needle is apt to be drawne awry) will be by an Instrument made in this manner. Provide a rect-

rectangular board about ten Inches long, and five broad: in the midst whereof, crosse the breadth, strike a Line perpendicular to the sides; and taking upon it a Center, describe a Circle intersecting the same Line, in two opposite points, to be noted with the Letters T. and A: divide each semicircle into two Quadrants, and every Quadrant into 90 Degrees, beginning at the points T and A, both wayes; the first Quad. beginning on the left hand of T. the second Quadrant on the right hand: the third Quadrant above it toward A: And lastly, the fourth Quadrant. And in the Center erect a Wier at right Angles.

The use of this Instrument. Apply the long side of the board next T to the Wall when the Sunne shineth upon it, holding it parallel to the Horizon, that it may represent an Horizontall plaine. Marke what Degree the shadow of the Wyer cutteth in the Circle; and instantly seek the Sunnes Azumith, either South or North: Reckon it on the Circle from the shadow to the Meridian, as was taught in the *Use* next before, noting that end with the Letter contrary to that of the Azumith: as if the Azumith bee South, note it N. and the opposite end S; if the Azumith bee North, note it S, and the opposite end N: whereby also you have the East and West sides: So shall the Arch S A.

or N A. give the Declination of the plaine: and the point A, the coast or quarter into which it is.

Example, *June* 2 in the forenoone, applying the instrument to a wall, I found the shadow in 23 Degr. of Quadr. 2. and the height of the Sunne was 26 Degrees, whereby I found the Azumith to be North 84 Degr. which reckoned from the shadow against the Sunne, fell upon 61 Degr. in Quad. 1. for one end of the Meridian; and the Opposite end, which is N. upon 61 Degr. in Quad. 3. And A was on the East side of N. Wherefore the Declination of that Wall is 61 Deg. from the North Eastward.

Use XIX. *To finde the Declination of an upright Wall by knowing the time of the Sunnes comming to it, or leaving it. And contrariwise, the Declination of an upright wall being known to finde at what time the Sunne will come into it.*

Because the Declination of a plain is an arch of the Equinoctiall intercepted between the Horizontall section of the plaine: and the East or West points: Or else (which is all one) between the Meridian, and A, the *axis* of that Horizontall sexion. Watch till you see the Center of the Sunne just even with the edge of the Wall: then instantly take the Sunnes Azumith from East or West, by *Use IX.* the same is the Declination of the wall. Like-

Likewiſe if the Declination be given, reckon it upon the Limbe of your Quadrant from the Eaſt and Weſt point; and the thread being applyed to the end of that Arch, ſhal in the *Suns* imaginary parallel for that day, cut the houre and time deſired.

Uſe XX. *Certaine advertiſements neceſſary for the uſe of the Quadrant in the night.*

In which Queſtions as concerne the night, or the time before *Sunne*-riſing, and after *Sunne*-ſetting, the inſtrument repreſenteth the lower Hemiſphere, wherein the *Southern* Pole is elevated. And therefore the parellels which are above the Equinoctiall toward the Center, ſhall be for the *Southerne* or winter parellels: and thoſe beneath the Equinoctiall, for the Northerne or *Summer* parallels: and the Eaſt ſhall be counted for Weſt, and the Weſt for Eaſt; altogether contrary to that which was before, when the Inſtrument repreſented the upper Hemiſphere.

Uſe XXI. *To finde how many Degrees the Sunne is under the Horizon at any time of the night.*

*S*eek the Declination of the *S*unne for the day propoſed by *Uſe I.* and at the ſame Declination on the contrary ſide of the Equinoctiall imagine a parallel for the *S*unne that night; and marke what point of it is in the very houre and minute

minute proposed: Set the bead to that point, then applying the thread to the scale of Altitudes, marke upon what Degree the bead falleth: for the same shall shew how many Degrees the Sunne is under the Horizon at that time.

Use XXII. *To finde out the length of the Crepusculum, or Twi-light.*

It is commonly held that Twilight is so long as the Sunne is not more then 18 degrees, under the Horizon, the question therefore is, at what time the Sunne cometh to be 18 Degrees under the Horizon any night.

Seek the Sunnes declination for the time proposed, and at the same declination, on the contrary side of the Æquinoctiall, imagine a parallel for the Sunne that night: then set the bead at 18 degrees in the scale of Altitudes; and carry the thread about till the bead fall upon the imagined parallell: for there shall be the houre or time sought.

And in this very manner you may find the time or houre of the night at any other depression of the Sunne under the Horizon.

FINIS.